

A STUDY OF THE ESKRIDGE SHALE

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1948

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology and Geography

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

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INTRODUCTION

Purpose of the Investigation

This investigation of the Eskridge shale was undertaken to develop an evaluation of the significance of color in shales in relation to sites of deposition. From data collected during the course of the investigation, more will be known of the lithologic and paleontologic characteristics of the Eskridge shale itself. The data collected and conclusions reached will add to the already vast quantity of material on sedimentation and paleogeography.

Definition of the Eskridge Shale

The Eskridge shale was named by Prosser (1902, p. 709) for exposures near Eskridge, Wabaunsee County, Kansas. The unit was described as the shale overlain by the Cottonwood limestone and underlain by the Neva limestone by Beebe (1902, p. 181). Southeastern Nebraska, eastern Kansas and north central Oklahoma comprise the outcrop area of this formation. Originally the Eskridge was classified as Upper Pennsylvanian (Wilmarth, 1938, p. 699), but more recently the formation has been classified as a part of the Council Grove group of the Wolfcampian series in the Lower Permian system (Moore, et al. 1944, p. 167), Plate I.

Area of Investigation

This study of the Eskridge shale covers the outcrop area of

EXPLANATION OF PLATE I

Generalized section of the Permian system
in Kansas showing the stratigraphic position
of the Eskridge shale.

PLATE I

Legend	Thickness (feet)	Member	Formation
	25		Speiser shale
	8		Funston limestone
	20		Blue Rapids shale
	12		Crouse limestone
	15		Early Creek shale
	6		Middleburg limestone
	10		Hooser shale
	7		Eiss limestone
	14		Stearns shale
	5		Morrill limestone
	7		Florina shale
	6		Callanwood limestone
	37	ESKRIDGE SHALE	
	20	Neva limestone	Grenola
	8	Salem Furner shale	limestone
	10	Burr limestone	
	20		Roca shale
	5	Howe limestone	
	7	Bennett shale	Red Eagle limestone
	9	Glenrock limestone	
	20		Johnson shale
	7	Long Creek limestone	
		Hughes shale	Foraker limestone
	40	Creek shale	
	3	America La.	

EXPLANATION

Limestone

Shale

Group	Series
Unnamed	Guadalupean
Nipewalla	
Leonardian	
Sumner	
Chase	
Council Grove	Woffcampian
Admire	

the formation in northeastern Kansas from the Nebraska line south into Chase County. The counties covered are: Nemaha, Pottawatomie, Jackson, Riley, Wabaunsee, Morris, Lyon, and Chase, Fig. 1. The outcrop area is only a few miles wide in the direction of the westerly regional dip and extends across Kansas toward the south in the direction of strike. The structural reflection of the Nemaha Ridge widens the outcrop belt in the northern part of the area.

Investigation Technique

Within its outcrop area, the Eskridge shale is exposed in road cuts, stream banks, and on hillsides. From these outcrops, some of them well exposed and complete and others poorly exposed and incomplete, 42 sections were measured. (See Appendix for the most nearly complete of these.) All existing exposures in the area were not examined because of limitations in time. Few sections less than 10 feet thick were measured. Descriptions of all sections measured in the course of this investigation are on file and available for reference in the office of the Department of Geology and Geography, Kansas State College.

After a useful outcrop was found, its geographic location was carefully determined to the quarter quarter quarter section, township, range, and county. The sections were assigned arbitrary numbers in sequence as they were measured within a county, Plate II. For example, W5 is the fifth section measured in Wabaunsee County.

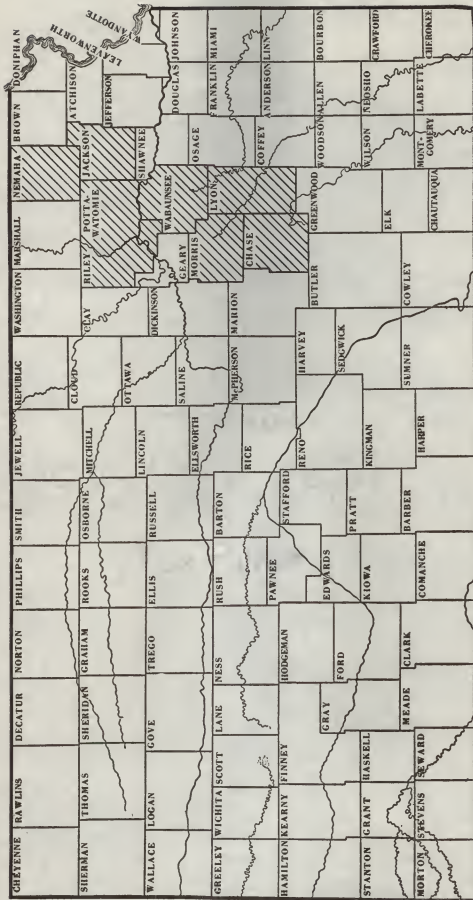
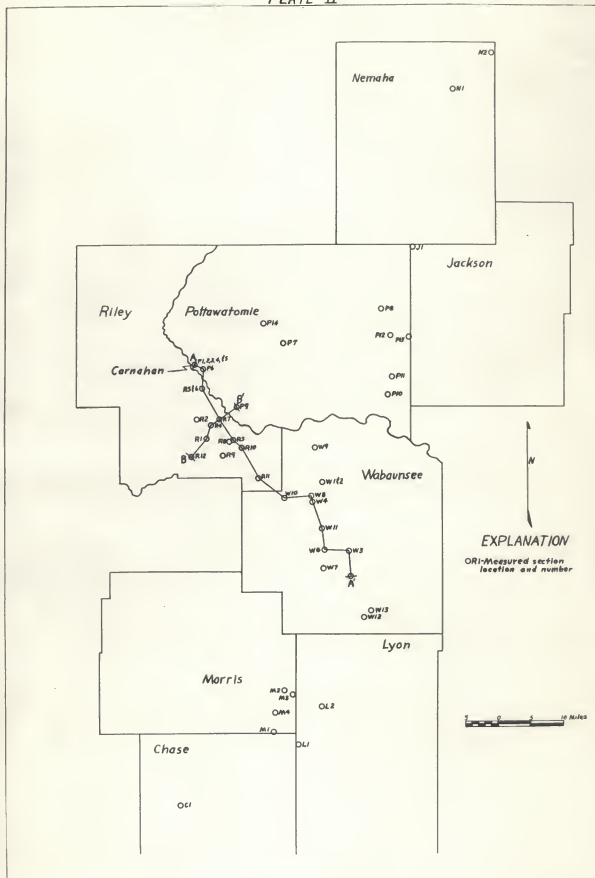


Fig. 1. Index map showing the area of this investigation.

EXPLANATION OF PLATE II

Map showing locations of measured sections
of the Eskridge shale, cross-sections A-A',
B-B', and the Carnahan cross-section.



Before actually measuring a section, the structural disposition of the beds was determined to eliminate inaccuracies in the use of the hand level. Thin mantle cover and weathered material were removed so that fresh rock was exposed.

The primary lithology, limestone or shale, and the secondary lithology, the kind of shale or limestone, were determined as described under Definition of Terms. Both the weathered and unweathered colors were determined by comparison with a color chart prepared by Dr. Frank E. Byrne. Fossils and primary structures, such as columnar concretions and oolites, were noted.

The thickness of each bed or zone was measured to the nearest tenth of a foot. When the sight distance was more than a few inches, a hand level was used for greater accuracy.

Definition of Terms

If the rock is indurated and very calcareous, it is called a limestone, or a shaly limestone if it has an earthy appearance. The limestone is termed blocky if it occurs in cubical blocks and platy if it is in slabs. The ease with which it is broken by a pick is the measure of its hardness and density.

Rock that is relatively soft and composed of silt-/and/or clay-size particles is classified as shale. The rate of effervescence in cold dilute hydrochloric acid is used to differentiate between very calcareous, calcareous, slightly calcareous, and noncalcareous shales. The presence of grit when a small piece is ground between the teeth is the field criterion for siltiness, and the absence of grit for clayeyness. The structure

is said to be: large blocky, when the rock breaks into rough cubes larger than 1.5 inches on a side; blocky, 1.5- to 0.75-inch cubes; small blocky, 0.75- to 0.25-inch cubes; granular, 0.25- to 0.05-inch cubes; mealy, a powdery material; massive, does not break into blocks; thinbedded, layers 0.5 to 0.05 inch thick; and very thinbedded, layers less than 0.05 inch thick.

Columnar concretions are hard calcareous structures that make rough, vertically oriented columns. The columns vary in diameter from about 0.5 inch to 2 inches. Oolites are small rounded grains, resembling rot, found in some of the limestones.

Office Procedures

All measured sections were drawn to a single scale. Shales were colored on the basis of the color of the shale, but limestones were not colored. Siltiness, clayeyiness, and calcareousness were recorded as marginal data in the graphic sections. These sections form the ultimate basis for all interpretations.

Three cross-sections are presented, Plates V, VI, and VII, to serve as the basis for an attempt to correlate beds directly and thus to establish a cyclical sequence in the deposition of the beds, if one exists. These were drawn with the base of the Cottonwood limestone as the datum. The horizontal spacing of the measured sections on the plates is in proportion to the actual distance between them.

To minimize some of the difficulties in direct correlation of beds, a series of drawings similar to bar charts was made,

Plate III. By reducing the measured sections to an arbitrary standard thickness, large variations in thickness are eliminated. Colors were assigned to represent deposition of the beds in different environments from the shore to moderately deep water. The cyclical advance and retreat of the shoreline is made apparent by this mechanism. Only some of the measured sections could be used for this purpose inasmuch as the total thickness of the formation had to be known.

An isopachous map was drawn to illustrate the distribution of variations in the total thickness of the formation, Plate IV. The isopachous lines connect points of equal thickness.

INTERPRETATION OF SECTIONS

General Description of the Eskridge Shale

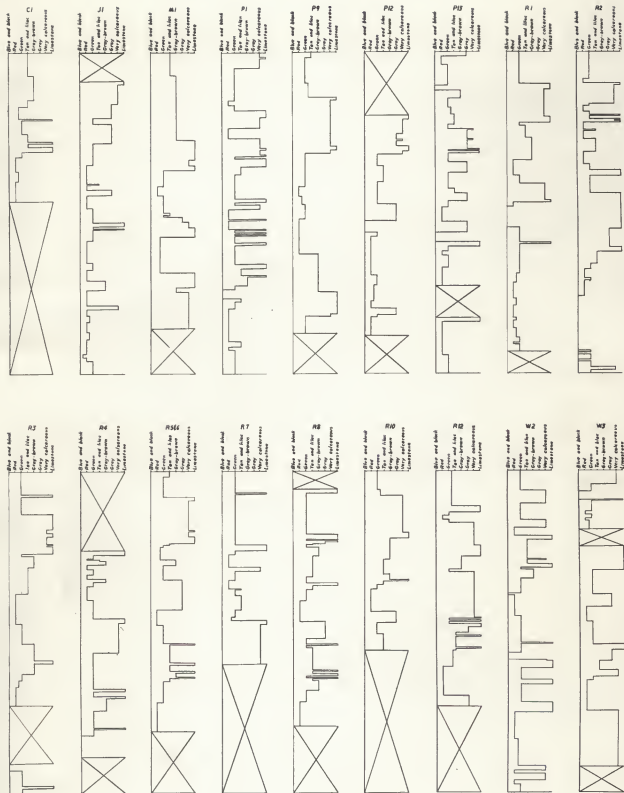
In the northern part of the area investigated, most of the nonmarine shales were deposited. The Eskridge shale has many lenticular limestones in the Manhattan area, while plant fossils occur in the southern part. Black shale exists on a general north-south line along the eastern side of the area studied. The formation varies in thickness from 42.9 to 27 feet.

In the following discussion the measured sections will be designated by their number within the county, as W5. Cross-section A-A', includes P1, P6, R5, R6, R7, R3, R10, R11, W10, W8, W4, W11, W6, W3, and W5. Cross-section B-B', Plate VI, includes P9, R7, R4, R1, and R12. The Carnahan cross-section, Plate VII, includes P1, P2, P3, P4, and P5. Measured sections that are not

EXPLANATION OF PLATE III

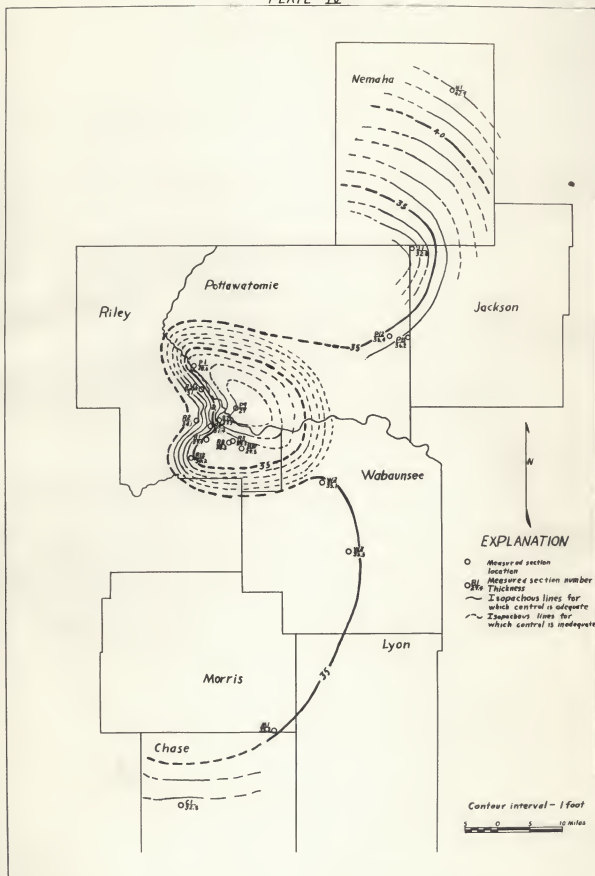
Bar charts of some of the measured sections
of the Eskridge shale.

PLATE III



EXPLANATION OF PLATE IV

Isopachous map of the total thickness of
the Eskridge shale.



included in one of the above cross-sections are J1, L1, L2, M1, M3, M4, P7, P8, P12, P13, R2, W1, W2, W7, W9, W12, and W13, Plate VIII.

Inherent Difficulties

Attempts were made by several means to correlate all individual layers in the Eskridge shale directly. This was found to be virtually impossible for two reasons: There is not a sufficient number of critically located sections available and, of the sections measured, only a few are more than 75 percent complete.

Even in an area as small as that centered around Manhattan, where closely spaced, nearly complete sections are available, correlation of individual beds is difficult. The correlation is quite exact for short distances and for a small portion of the total section. But the correlation of all of the beds in the formation over an extensive area cannot be developed with the information at hand. Further, rapid variations occur laterally, but the variations are not necessarily in the same direction. (See later section on Shift of Lagoonal Axes.)

The Carnahan cross-section illustrates the rapid lateral variations in the Eskridge shale. A road-cut exposure was measured at five places at intervals of 90 feet to determine the extent of variations within a short distance. The second limestone from the top in P2 and P3 is present only in these two sections. Rapid lateral variation is displayed in the limestone 15 feet

below the Cottonwood limestone as shale zones lense in to it. The beds of shale show variations both in color and thickness. In some instances, however, such as the uppermost layer of limestone, in the formation, some of the beds are very consistent in lithology and thickness.

From the southeastern corner of Morris County northeast through central Wabaunsee County, and along the eastern edge of Pottawatomie County there is a series of sections (M3, M4, W12, W13, W1, W2, P11, P12, and P13) in which black shales are present, Plate II. Of these, only those in northern Wabaunsee and southern Pottawatomie Counties show a discernible relationship. Toward the south the beds of black shale are in entirely different parts of the section and, therefore, must have been deposited at different times.

The occurrence of fossils of land plants indicates the presence of a shore facies in this area at various times during the interval in which the Eskridge shale was deposited. The trend of the dark-colored shale is the same as that of the Nemaha Ridge, a relationship that might be coincidental rather than causal.

In Lyon County, L1 and L2 show little relationship to any of the nearby sections. Limestones are mostly lacking, whereas green and red shales are present in abundance and tan and gray shales occur in lesser thicknesses. This probably represents the shore facies related to the marine facies developed in Morris County toward the west.

Thickness

The total thickness of the Eskridge shale varies considerably over the area covered by this report. Although the variations are quite large, there is a discernible pattern, Plate IV.

In northern Nemaha County the Eskridge shale is 42.9 feet thick, while near the southwestern corner of Pottawatomie County it is only 27 feet thick. The Manhattan area is apparently a region in which the Eskridge shale has the least total thickness. Incomplete outcrops make it impossible to determine definitely but the position of isopachous lines indicate that the Manhattan area and eastward is a region of isolated thinning, Plate IV. The formation thickens toward the northwest to the point of maximum observed thickness and also toward the south. This might mean that the formation also increases in thickness from eastern Pottawatomie County across the Kansas River into central Wabaunsee County.

Color, Lithology, and Environment

Interpretation of Blue Shales. Blue sediments (Twenhofel, 1926, p. 196) may be deposited in enclosed or partially enclosed bodies of water, but they may also be formed (Elias, 1937) as a transitional zone between red and green sediments. In R2, near the base, a thick bed of blue shale occurs between maroon and green zones and lower in the section it is in green shale.

The blue shale at the base of R4 is adjacent to green shale and 13.3 feet lower in P4 green shales overlie and underlie a thin blue shale. Also near the base of P4 blue shale is found adjacent to green and gray shales. At the base of W3, a blue zone is below maroon. A blue shale lies between gray and green 16 feet below the top of W5. Blue shale is commonly associated with green but is not always with red.

The infrequent occurrence and lack of persistence laterally in the measured sections indicate that blue shale is not a simple transition between red and green. Instead, the existence of special conditions of deposition, as enclosed or partially enclosed bodies of water, appears to be necessary.

Interpretation of Red Shales. The red shales, including maroon, purple, and pinkish-violet, have such a color because of the presence of ferric oxide and the absence of organic material. If organic material is present, reduction to ferrous oxide takes place (Twenhofel, 1926, p. 193; Pettijohn, 1949, p. 173). For a sediment to be red because of the presence of ferric oxide when organic material is also present, it must be deposited on land or in the tidal zone. In the writer's opinion most of the red shales of the Eskridge are marine and were deposited in the absence of organic material. The reason for this belief is the similarity of red shale to other colors of shale in the formation in every respect except color. In some instances, however, as at the base of J1, the red shale is conspicuously different from the normal texture of other Eskridge shales. The red shale here

is hard and not plastic, leading to the belief that it is a non-marine deposit.

Interpretation of Green Shales. Green shales, ranging from light-green through gray-green to dark-green, are probably deposited under marine conditions near shore with some organic material to reduce the red ferric iron to the ferrous state (Elias, 1937, p. 403-432; Pettijohn, 1949, p. 173). The position of the green shale, immediately adjacent to maroon, in all of the sections indicates this to be true.

Interpretation of Tan Shales. In R10, R3, P4, and W13, tan, tan-gray, yellow, and lilac shales are associated with limestones and probably represent the transition from limestones to green shales. This position indicates them to have been deposited at a somewhat greater distance from the shore.

Interpretation of Gray Shales. The olive-drab, gray-brown, and gray have a position, in the measured sections, indicative of a gradational sequence to deeper water sediments. This is illustrated in R10, P3, P4, and W13.

Gray shale, colored by finely divided carbon of organic origin, may also be deposited in a shore or near-shore environment (Twenhofel, 1926, p. 196). The association of the gray shales with black and maroon shales in W7, W13, and W5 demonstrate this as a probability.

Interpretation of Calcareous Shales. The very calcareous shales, shaly limestones, and crystalline limestones complete the depositional sequence seaward. Many of the very calcareous

shales immediately beneath the Cottonwood limestone probably contain an appreciable amount of secondary calcium carbonate. This is evident from the presence of geodes and other secondary calcareous deposits.

Fluctuations of the Shoreline

As a unit, the Eskridge shale represents a major cycle of deposition in water shallower than that in which the underlying Neva limestone and the overlying Cottonwood limestone were deposited. Within the unit, however, there are discernible minor depositional cycles.

This is best shown by cross-section A-A'. Immediately below the Cottonwood limestone is a series of shales and lenticular limestones which varies from about 3 to 8 feet thick. The shales are predominantly green, but tan, gray, and maroon shales are also present. This represents near shore deposition with shoreline fluctuations in both shoreward and seaward directions.

Just below the shales is a limy zone indicating deposition in somewhat deeper water. In P1, 5.2 feet below the base of the Cottonwood limestone, is a hard limestone that is a foot lower but equally well developed in R5. This limestone carries through at about the same level to R7 and R3 where it thickens slightly, and is present at the base of a limy zone. The limestone is exposed in R10 about a foot higher in the section than in R3. In R11 the unit is represented by a much thicker shaly limestone and carries on to W10, where a correlative limy zone is present some-

what lower in the section.

A less-thick, dense limestone is present in W8 at the same elevation as in W10, which correlates with another thick limy zone in W4. Section W11 shows only thin lenticular limestones in a zone of very calcareous shales 5.7 feet thick, and 3.8 feet below the base of the Cottonwood limestone.

In W6 the trend is broken by a limestone 2.4 feet below the Cottonwood limestone, instead of at the elevation of the persistent limestone bed. The limestone reappears in W3 with the top 8.3 feet from the Cottonwood, and is present in a slightly lower position in W5.

The environment of deposition changed to shore or near-shore conditions, and maroon and green shales were deposited. A clear-cut transition from deep to shallow marine to land deposition is not also evident, but is shown fairly well in R10. From the layer of limestone 6 feet below the base of the Cottonwood limestone there is a transition downward through gray-brown, tan, back through gray-brown shales to a lenticular limestone, representing a very minor fluctuation. Downward from the lenticular limestone are, in order, tan, light-green, and maroon shales. Many of the sections, as W8, show very rapid and apparently erratic fluctuations.

The maroon shale of R10 is present at a slightly lower level in R7, R5, P6, and P1. Incomplete sections make direct correlation difficult, but a maroon shale is present in the central portion of the complete sections, and at a corresponding level in

the incomplete sections.

This general sequence of maroon shale to limestone, to maroon shale is again repeated in the lower half of the Eskridge shale. Other sections, P9, W2, and P8, not included in these cross-sections, will aid in illustrating these cyclical variations since they are nearly complete sections. Deposition began much as it ended, green shales predominating, with a more landward environment because of the lack of tan shale.

Generally, the Eskridge shale is made up of two minor depositional cycles, illustrated by the two limestone zones and the intervening maroon shales, within the major cycle.

Correlation of Lateral Gradations

Correlation laterally of individual layers is not a direct one (Krumbein, 1947, p. 101-108). Instead there is a change of facies (Moore, 1949, p. 1-18) with time correlation. That is, a limestone should correlate horizontally with successively different types of shale as shore is approached.

This characteristic is well demonstrated in cross-section A-A'. Assuming that time lines are horizontal, the limestone 3.8 feet below the Cottonwood limestone in R3 would correlate with many different colors of shale. While the basal 0.9 foot limestone was being deposited, maroon shale, green shale, and then limestone were being deposited in R7. At the same time, in R5, green shale, a thin tan shale, and some limestone were being laid down. P6 shows gray shale, while P1 shows maroon and then very

calcareous green shale as the units that are time equivalents of the limestone in R3. The lateral correlation with the very calcareous green shale of R3 is: R7, limestone and green shale; R5, limestone and very calcareous cream shale; and P1, very calcareous green shale. The next thin limestone in R3 is equivalent to: green shale, very calcareous cream shale, a lenticular limestone, and a hard limestone.

The interpretation based upon this evidence is that land was in the direction of P1. Limestone was deposited there last with green and maroon shale being deposited at the same time as the limestone of R3. During this interval of deposition, the area was subsiding as the shoreline transgressed toward the east.

The extreme variation along time lines is one of the outstanding characteristics of the Eskridge shale.

In a few instances, lateral variation in sediments was observed but with fossils remaining to mark the single horizon. In P2, 17.6 feet below the Cottonwood limestone, there is a thin limestone containing Aviculopecten, and a similar limestone is present in P4 at about the same level. The limestone is absent in P1, but the fossils are present in a shale at the same position in the section.

In R12, 16.4 feet below the Cottonwood limestone, is an Aviculopecten limestone. This bed appears to be correlated with a thin nonfossiliferous limestone, a short distance lower in R1. At approximately the same level in R4 as in R1 is Aviculopecten in a gray shale, indicating a lateral transition from limestone to gray shale.

Rate of Fluctuations

The rate of fluctuation of the shoreline is recorded in the thickness of any one kind of material deposited; that is, a thick unit of constant lithology indicates rather stable conditions, while a series of thin units indicates rapidly changing conditions.

In the area covered by cross-section A-A', variations were not at the same rate. There is a series of thin layers in the upper parts of W3, W6, W4, R7, and P1. The remainder of the sections, W11, W8, W10, R11, R10, R3, and R5, show thicker units. The shoreline must have been fluctuating at different rates in these different areas. Lower in the section, at a time equivalent to the limestone below the covered interval of W3, conditions were different. For this period of deposition W3, R11, R3, and R5, were in relatively stable areas, and P1, P6, R7, R10, W10, W8, W4, W11, and W6 in areas of more rapid fluctuation. The areas represented by W11, W8, W10, and R10 changed from depositional stability to instability, while the area of W3 changed from unstable to stable. Therefore, the rate of fluctuations was not only different in different areas but also for different times in the same area.

Fossil Facies

Fossils in the limestones of the Eskridge shale are widespread, but not markedly persistent, cross-section A-A'. The

most abundant fossil is Aviculopecten, occurring at several levels in numerous sections. Myalina is numerous in the area around Manhattan, but is not so common throughout the region generally. This may be because Myalina occurs most commonly in the lower part of the Eskridge shale, and the sections in other areas do not show the basal part of the formation. Pseudomonotis is not abundant but is notable because it occurs most commonly in the limestones near the top of the formation. The fossil Pleurophous occurs occasionally and is present in M1, P3, P10, and R3. Septimyalina occurs only in R2, M1, and W9, while Marginifera occurs in the upper portions of R5, R3, P8, P3, P5, P7, P11, W3, and W10. Bellerophon is present in the middle and lower portions of R2, R4, and R8 only, so is restricted in its areal extent. Unique in their occurrence are Astartella in R8, and Loxonema in W9. Fragments of what appeared to be Derbyia were found in several places. The plant fossil Neuropteris was found only in the black shales of M3, M4, W12, and W13.

According to Elias (1937, p. 403-432), this fossil assemblage would indicate that the Eskridge shale was deposited in marine water that was never very deep. The limestones containing both mollusks and brachiopods represent deposition in the deepest water, a maximum of approximately 110 feet. Since the brachiopods are not abundant, the Eskridgian sea in this area probably was never much more than 90 feet deep.

The plant fossil, Neuropteris, and tree bark that were found well preserved would indicate that the material was not moved far

from a region where the plants lived. The presence of the plant fossils is significant, since a nearby land area must have been present to supply the organic material.

Shift of Lagoonal Axes

Lagoonal axes, which are the lines through the deepest parts of the different depositional sites, appear to shift. In R1, R2, R4, and R5, Plate II, the two limestones approximately 3 and 6.5 feet below the Cottonwood limestone correlate fairly well. There is a reasonable correlation of the limestones approximately 13.5 feet below the Cottonwood limestone in R1, R2, and R4, but no limestone exists at this level in R5.

A different condition exists when considering the thick limestone 15 feet below the Cottonwood in R2. Only in R4 is there a limestone and a very calcareous shale that will correlate with the thick limestone of R2. The fossiliferous limestone, 22 feet below the Cottonwood in R2, will correlate with a similar limestone in both R4 and R5, but not in R1.

The region was not raised and lowered as a unit, but different parts raised and subsided at different times. This being the case, one measured section does not show the same relationship to the other sections in the area. This assumption seems to be corroborated by the preceding discussion of the rate of fluctuation.

CONCLUSIONS

The Eskridge shale was deposited in both marine and nonmarine environments. The nonmarine sediments are represented by red and black shales. All other types of shale and limestone represent the marine phase. The transition from the red nonmarine shales to the deepest marine condition is through: blue or gray, green, tan, gray-brown, gray, very calcareous shale, shaly limestone, and limestone.

The maximum depth of deposition was in water about 90 feet deep as represented by the kinds of fossils present. The shoreline was constantly fluctuating in position, and not always at the same rate. Further, the shoreline was irregular and many lenticular beds were deposited which cannot be directly correlated over wide areas.

There is a consistent variation in total thickness from 27 to 42.9 feet.

ACKNOWLEDGMENTS

The author wishes to express appreciation to Melville R. Mudge, Glenn Scott, and Carl F. Crumpton, all of the U. S. Geological Survey, for information on the locations of exposures of Eskridge shale. The writer expresses gratitude to Dr. Frank E. Byrne for making available information on the location of Eskridge shale exposures and for numerous technical suggestions and advice in writing this report.

LITERATURE CITED

- Beebe, J. W.
Coal measures faunal studies, II. Kans. Univ. Sci. Bul. 1:
181. 1902.
- Elias, M. K.
Depth of deposition of the Big Blue (Late Paleozoic) sedi-
ments in Kansas. Geol. Soc. Amer. Bul. 48:403-432. 1937.
- Krumbein, W. C.
Shales and their environmental significance. Jour. Sed.
Petrol. 17(3):101-108. 1947.
- Moore, R. C.
Meaning of facies. Geol. Soc. Amer. mem. 39. 1-18. 1949.
- Moore, R. C., J. C. Frye, and J. M. Jewett.
Tabular description of outcropping rocks in Kansas. State
Geol. Survey Kans. Bul. 52. 167. 1944.
- Pettijohn, F. J.
Sedimentary rocks. New York: Harper and Brothers. 173.
1949.
- Prosser, Charles S.
Revised classification of the Upper Paleozoic formation of
Kansas. Jour. Geol. 10:709. 1902.
- Twenhofel, W. H.
Treatise on sedimentation. Baltimore: Williams and Wilkins.
193 and 196. 1926.
- Willmarth, M. G.
Lexicon of geologic names of the United States. U. S. Geol.
Survey Bul. 896. 699 p. 1938.

APPENDIX

Examples of the Detailed Description of Measured Sections

Measured Section No. J1

Road out in the NE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 6 S., R. 12 E.
(Jackson Co., Kans.):

	Feet
Cottonwood limestone member of the Beattie limestone	
Eskridge shale	
Covered interval	3.0
Limestone, shaly; massive, weathers blocky; dense, soft; cream .....	.3
Shale, silty, very calcareous; small blocky, weathers granular; light-green with brown stains, weathers cream	2.0
Shale, silty, calcareous; small blocky, weathers granular; gray with brown surface stains, weathers light-gray	1.4
Shale, silty, calcareous; small blocky, weathers granu- lar; gray-green, weathers light-gray .....	.6
Shale, silty, calcareous; large blocky, weathers thin- bedded; light-gray with dark-gray horizontal streaks in lower part, weathers light-gray	2.0
Shale, clayey, calcareous; mealy; gray-green, weathers light green .....	.5
Shale, clayey, calcareous; blocky, weathers granular; dark-green, weathers gray-green .....	.7
Shale, silty, calcareous; mealy; gray-green, weathers light-green	1.0
Shale, silty, calcareous; massive, weathers mealy; pinkish-violet, weathers lilac; thin yellow layer 0.5 feet from base	2.5
Shale, silty, calcareous; massive, weathers mealy; gray, weathers light-gray .....	.6
Shale, silty, calcareous; blocky, weathers small blocky; small mottled maroon and gray-green, weathers pinkish- violet	1.3
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers light-green	1.5
Limestone; finely crystalline, massive, dense, very hard; tan-gray; oolites on upper surface .....	.4
Shale, silty, calcareous; thinbedded; gray-green, weathers light-green .....	.2
Limestone, shaly; massive, weathers blocky; gray, weathers light-green. <i>Aviculopecton</i> , <i>Myalina</i> .....	.1
Shale, silty, calcareous; small blocky, weathers granular; gray-green, weathers light-green	1.2
Shale, silty, calcareous; blocky, weathers granular; pinkish-violet	2.2

Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers light-green	0.7
Shale, silty, calcareous; blocky, weathers granular; maroon	1.1
Shale, silty, calcareous; large blocky, weathers granular; brown, weathers lilac	1.0
Shale, silty, calcareous; blocky, weathers granular; maroon	1.6
Shale, silty, very calcareous; large blocky, weathers blocky; maroon with light-green spots, weathers maroon..	.4
Shale, silty, calcareous; blocky, weathers granular; maroon .....	.6
Shale, silty, calcareous; massive, weathers granular; mottled gray-green and maroon, weathers lilac .....	.6
Shale, silty, calcareous; blocky, weathers granular; maroon	1.1
Shale, silty, calcareous; massive, weathers granular; mottled gray-green and maroon, weathers lilac .....	.7
Shale, silty, calcareous; blocky, weathers granular; maroon; very calcareous, hard horizontal stringers	1.5
Shale, silty, calcareous; small blocky, weathers granu- lar; mottled maroon and gray, weathers maroon .....	.4
Shale, silty, calcareous; blocky, weathers granular; maroon .....	.3
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers light-green	<u>1.2</u>
Total thickness	32.8

Neva limestone member of the Grenola limestone.

Measured Section No. R2

Road cut along Highway U S-40 in the NE $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 10,
T. 10 S., R. 7 E (Riley Co., Kans.):

	Feet
Cottonwood limestone member of the Beattie limestone	
Rakridge shale	
Shale, silty, noncalcareous; small blocky, weathers granular; gray-green with brown surface stains, weathers light-green to cream	2.9
Shale, clayey, calcareous; small blocky, weathers granular; maroon; lenticular within 15 feet .....	.5
Limestone; finely crystalline, nodular, porous, very hard; lilac, weathers cream .....	.2
Shale, silty, very calcareous; massive, weathers mealy to nodular; light-gray, weathers white	1.4
Shale, silty, very calcareous; blocky; lilac .....	.6
Shale, silty, calcareous; massive, weathers mealy; light-green .....	.2

Shale, silty, calcareous; large blocky, weathers thinbedded; pinkish-violet, weathers lilac	0.6
Shale, silty, calcareous; blocky, weathers thinbedded; light-green; transitional upper contact .....	.4
Limestone, shaly; massive, weathers platy; soft; light-gray .....	.1
Shale, silty, calcareous; blocky, weathers thinbedded; light-green .....	.3
Limestone; finely crystalline, massive, weathers blocky; dense; light-gray. <u>Aviculopecten</u> .....	.1
Shale, clayey, very calcareous; thinbedded; light-green ..	.1
Limestone, shaly; massive, weathers blocky, dense; light-gray; oolites. <u>Aviculopecten</u> .....	.2
Shale, silty, calcareous; small blocky, weathers granular; maroon .....	.7
Shale, silty, calcareous; small blocky; tan; no weathered exposure .....	.1
Shale, silty, calcareous; small blocky, weathers granular; maroon .....	.9
Shale, silty, calcareous; blocky, weathers granular; tan..	1.4
Shale, silty, calcareous; blocky, weathers granular; maroon, weathers lilac	1.3
Shale, silty, calcareous; small blocky, weathers granular; light-green .....	.6
Limestone, crystalline, massive, weathers platy with wavy laminations; dense, hard; light-gray .....	.6
Shale, silty, calcareous; thinbedded, weathers mealy; light-green .....	.3
Shale, clayey, slightly calcareous; blocky, weathers granular; dark-green, weathers gray-green .....	.9
Shale, silty, calcareous; thinbedded, weathers mealy; light-green .....	.6
Limestone, shaly; massive, weathers blocky; soft; gray, weathers light-gray .....	.4
Limestone, very shaly with irregular layers of thinbedded shale; platy, dense, soft; mottled light and dark-gray, weathers light-gray	3.4
Shale, silty, calcareous; large blocky, weathers thinbedded; gray, weathers light-gray	2.0
Limestone; finely crystalline, massive, weathers blocky; dense, hard; light-gray with tan stain. <u>Aviculopecten</u> , <u>Septimyalina</u> .....	.2
Limestone, very shaly; platy, dense, soft; light-gray; <u>Aviculopecten</u> , <u>Myalina</u> , <u>Bellerophon</u> .....	.3
Shale, silty, calcareous; massive, weathers mealy; laminated; red-brown, weathers tan .....	.1
Shale, silty, calcareous; blocky, weathers granular; tan..	1.1
Shale, silty, slightly calcareous; small blocky, weathers granular; dark-green, weathers gray-green .....	.6
Shale, silty, calcareous; small blocky, weathers granular; hard; maroon	1.0

Shale, silty, calcareous; small blocky, weathers granular; hard; dark-green, weathers gray-green	0.2
Shale, silty, calcareous; blocky, weathers granular; hard; maroon, weathers lilac	1.6
Shale, silty, slightly calcareous; massive, weathers granular; hard; gray-blue, weathers turquoise	1.6
Shale, silty, slightly calcareous; massive, weathers concretionary; hard; blue-gray, weathers turquoise; numerous columnar concretions	4.2
Shale, silty, calcareous; thinbedded; gray-green, weathers light-green .....	.2
Shale, silty, calcareous; small blocky, weathers granular; blue-gray .....	.2
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers light-green .....	.6
Shale, silty, calcareous; blocky; mottled gray-green and blue-gray; no weathered exposure; transitional upper and lower contacts .....	.2
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers light-green .....	.6
Shale, silty, very calcareous; massive, weathers mealy; hard; gray-green, weathers light-green .....	.3
Shale, silty, calcareous; granular, weathers mealy; gray-green, weathers light-green .....	.3
Total thickness	34.1

Neva limestone member of the Grenola limestone

Measured Section No. W3

Road cut in the NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 17, T. 13 S., R. 11 E.
(Wabaunsee Co., Kans.):

	Feet
Cottonwood limestone member of the Beattie limestone	
Eschridge shale	
Shale, silty, very calcareous; blocky, weathers granular; tan	0.8
Shale, silty, very calcareous; blocky; hard; tan-gray, weathers tan .....	.6
Shale, silty, calcareous; small blocky, weathers granular; light-green .....	.8
Shale, silty, calcareous; small blocky, weathers granular; turquoise .....	.9
Limestone; finely crystalline, blocky, dense, hard; gray, weathers light-gray .....	.1
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers light-green .....	.8
Shale, clayey, calcareous; blocky, weathers granular; dark-green, weathers blue-green .....	.4

Shale, clayey, calcareous; blocky, weathers granular; maroon, weathers lilac	0.3
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers light-green .....	.4
Shale, silty, calcareous; small blocky, weathers granular; maroon with white nodules .....	.3
Shale, silty, noncalcareous; mealy; light-green with maroon filling in cracks, weathers maroon .....	.2
Shale, silty, noncalcareous; mealy; light-green with dark-green filling in cracks, weathers light-green .....	.2
Shale, silty, noncalcareous; mealy; light-green with maroon smudges, weathers light-green .....	.5
Covered interval	1.9
Limestone, finely crystalline, massive, weathers platy; dense, hard; gray, weathers light-gray; upper part has oolites .....	.5
Limestone, shaly; massive, weathers platy; dense, soft; light-gray .....	.5
Limestone; finely crystalline, massive, weathers platy; dense, hard; light-gray. <u>Marginifera</u> , <u>Pseudomonotis</u>	1.6
Shale, clayey, calcareous; granular, weathers mealy; light-green .....	.6
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers turquoise	2.0
Shale, silty, calcareous; blocky, weathers granular; gray, weathers light-gray	1.4
Shale, silty, calcareous; blocky, weathers granular; maroon with lilac spots, weathers lilac	1.6
Shale, silty, calcareous; blocky, weathers granular; gray-green, weathers gray	2.5
Limestone, shaly; massive, weathers thin platy; dense, very hard; gray, weathers light-gray .....	.6
Shale, silty, calcareous; blocky, weathers granular; gray-brown	1.2
Shale, silty, calcareous; mealy, weathers nodular in upper part; yellow, weathers tan	1.0
Shale, clayey, very calcareous; mealy; white with gray-green stringers .....	.7
Shale, clayey, calcareous; small blocky, weathers granular; dark-green, weathers turquoise .....	.4
Shale, silty, slightly calcareous; blocky, weathers granular; maroon	3.2
Shale, clayey, noncalcareous; small blocky, weathers granular; purple .....	.2
Shale, silty, very calcareous; mealy; maroon .....	.8
Shale, silty, very calcareous; massive, weathers mealy and upper part nodular; turquoise with occasional spot of gray-blue	5.5
Covered interval	3.0

Total thickness 35.5

Date Due

Oct 17 '57 M